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(56) Documents Cited
GB 2121971 A
EP 0391242 A
US 5454710 A
US 3808522 A
EP 0447928 A
FR 002734061 A1
US 4888716 A

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UK CL (Edition T) H2K KSX
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(54) Abstract Title
Monitoring battery performance during operation

(57) An instrument for monitoring and indicating electrical battery health by comparison of in-service performance with performance measured when the battery was first installed. Data is automatically collected through accurate monitoring and recording of battery terminal voltage during normal operation, and by applying periodic calibrated loads. By comparing collected data with that collected when the equipment was new, an indication of health, relative to that when new, is given. The output may be used by machine operators and/or machine systems to avoid failure of the associated machine because of poor battery condition, to minimise the effects of a failure, and to schedule maintenance including a battery replacement strategy. The instrument may be used on a tractor or a boat.

Figure 1

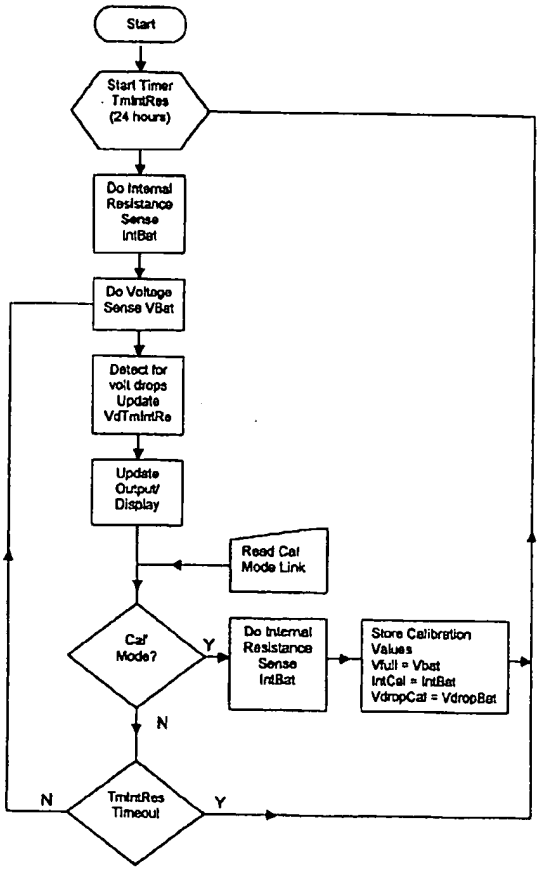

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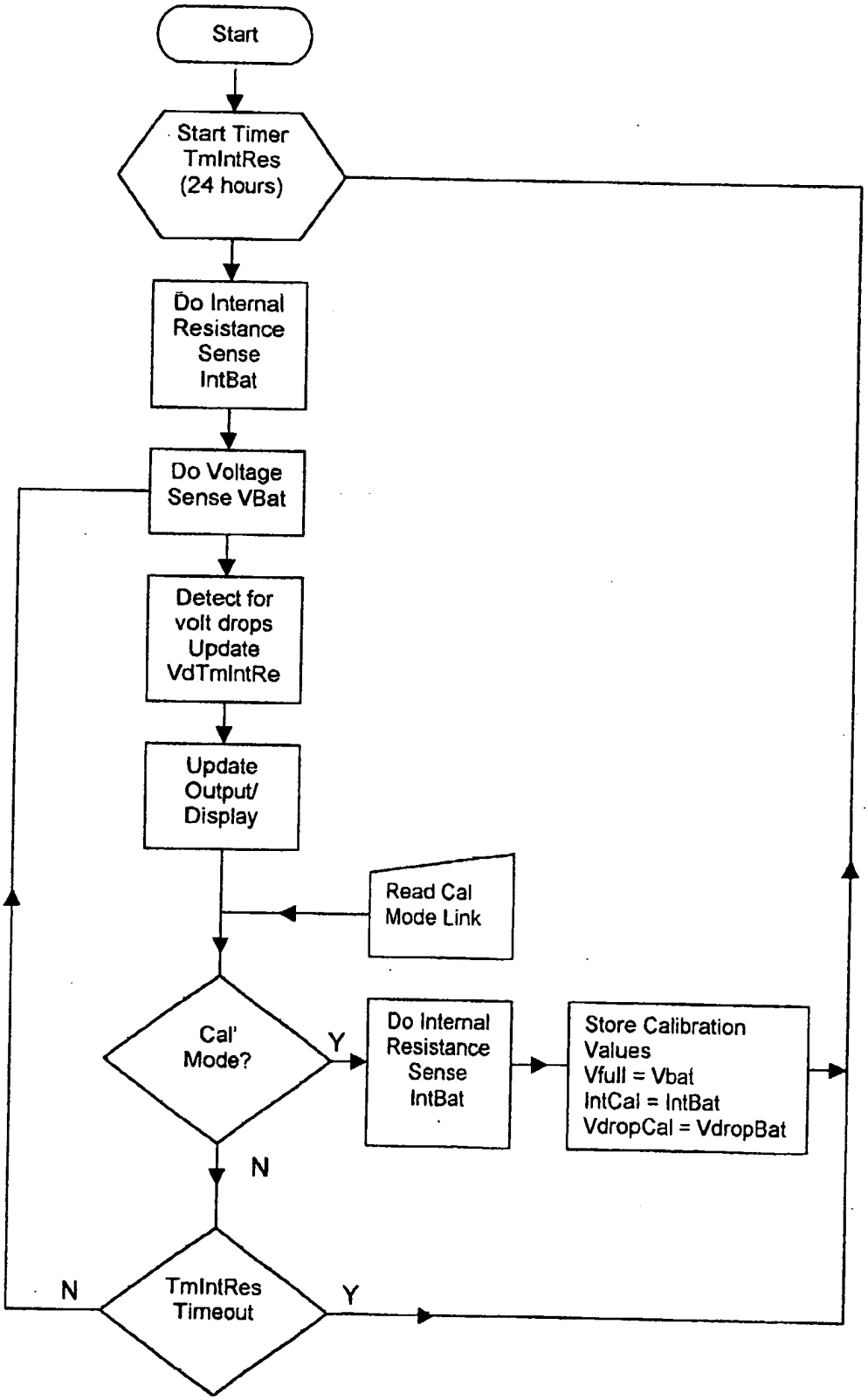
Figure 1


Start
Start Timer TmIntRes (24 hours)
Do Internal Resistance Sense IntBat
Do Voltage Sense VBat
Detect for volt drops Update VdTmIntRe
Update Output/ Display
Read Cal Mode Link
Cal' Mode?
Y
Do Internal Resistance Sense IntBat
Store Calibration Values Vfull = Vbat IntCal = IntBat VdropCal = VdropBat
N
TmIntRes Timeout
N
Y

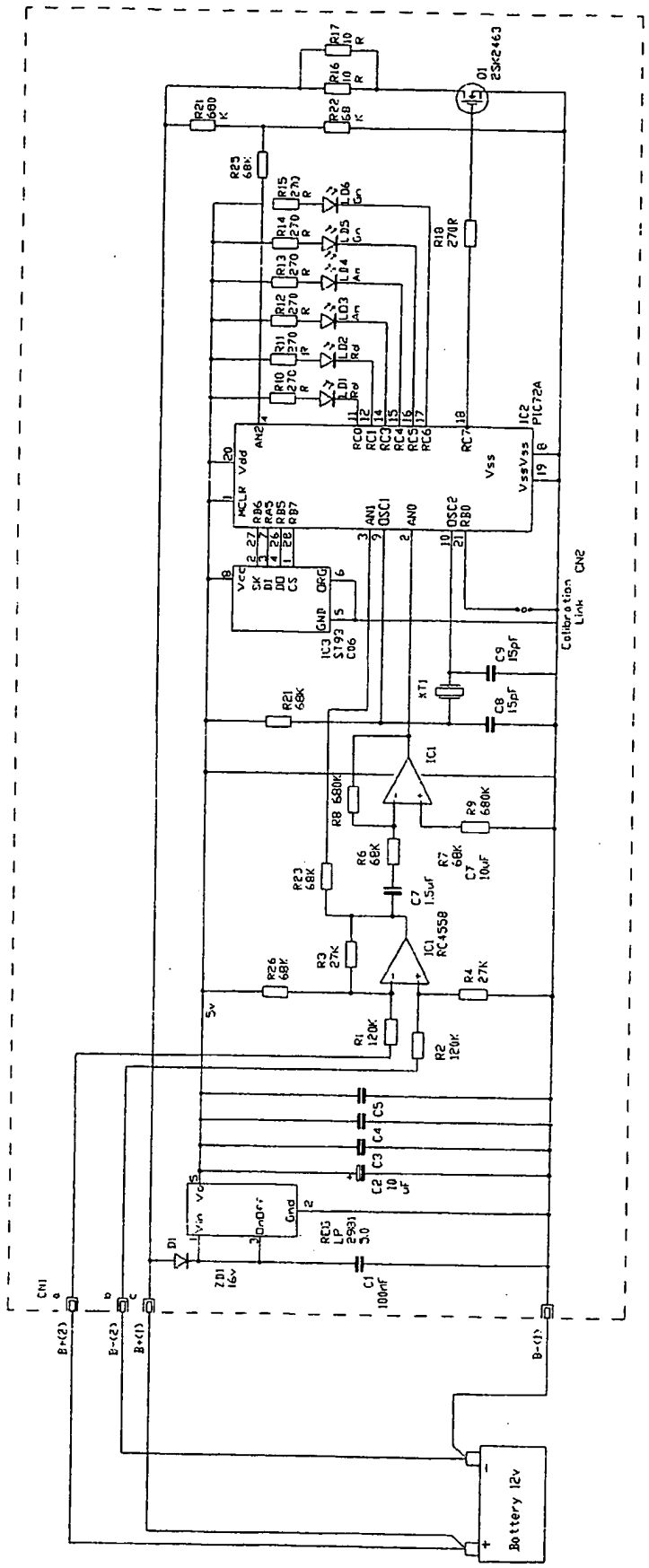

Q1
2SK2463
R17
10
R
R16
10
R
R21
680
K
R22
68
K
R25
68K
R15
270
R
R14
270
R
R13
270
R
R12
270
R
R11
270
R
R10
270
R
R18
270R
LD6
Grn
LD5
Grn
LD4
Am
LD3
Am
LD2
Rd
LD1
Rd
IC2
PIC72A
AN2
Vdd
MCLR
RB6
RA5
RB5
RB7
AN1
OSC1
AN0
OSC2
RB0
Vss
Vss
RC0
RC1
RC3
RC4
RC5
RC6
RC7
IC3
S193
C06
Vcc
SK
DI
DO
CS
ORG
GND
Calibration
Link
CN2
C9
15pF
C8
15pF
XT1
R21
68K
IC1
R8 680K
R9
680K
R6
68K
R7
68K
C7
1.5uF
C7
10uF
R23
68K
IC1
RC4558
R3
27K
R4
27K
R26
68K
5v
R1
120K
R2
120K
C5
C4
C3
C2
10
uF
REG
LP
2951
5.0
Vin
Vout
On-Off
Gnd
D1
ZD1
16v
C1
100nF
CN1
B+(2)
B-(2)
B+(1)
B-(1)
Battery 12v

Figure 2

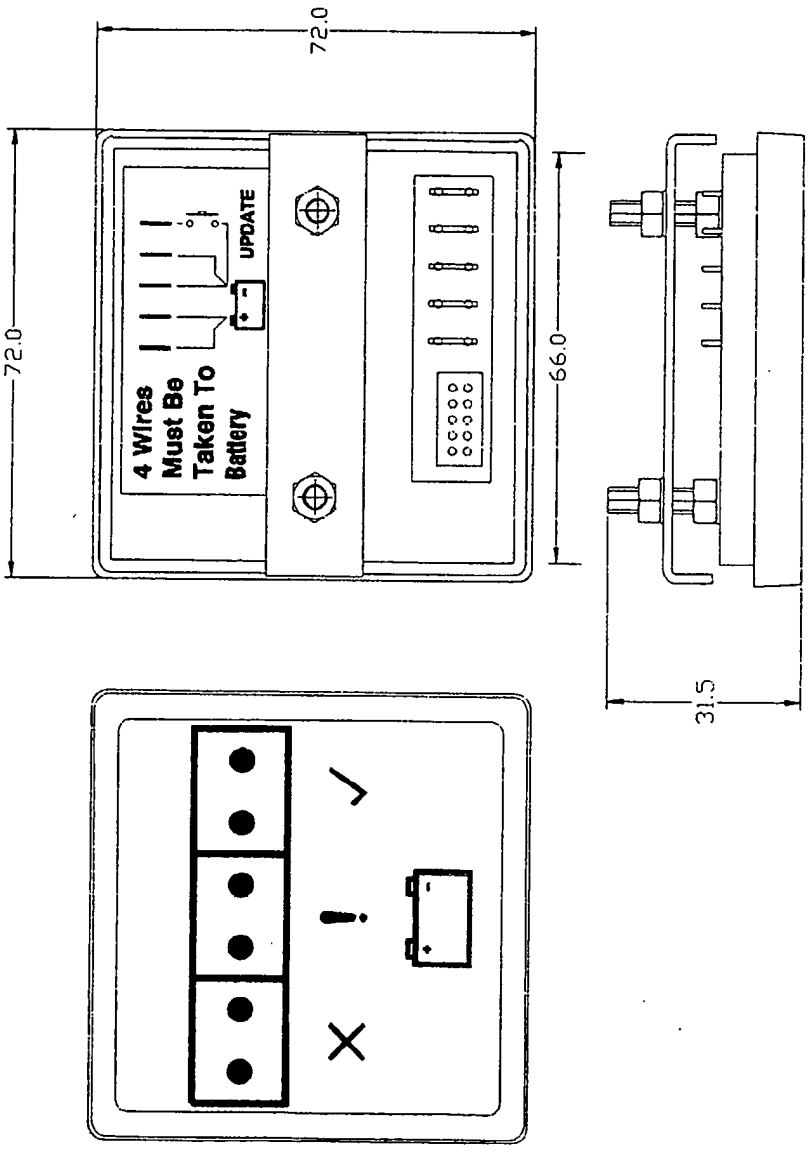


Figure 3

Battery "In Service" Health Monitoring Instrument

The invention relates to an instrument for indicating the health of a battery. Example applications include monitoring starting batteries of engine driven machines and batteries used for energy storage in un-interruptible power supply systems.

It is designed for continuous connection to a battery, either mounted on, or integrated into, the battery casing, or mounted on the machine incorporating the battery. A typical application would be monitoring of engine starting batteries on a piece of agricultural machine such as a tractor.

Instruments for indicating battery voltage, charge and loading are well known (e.g. voltmeter, ammeter). Interpretation of readings requires a technical understanding of the machine electrical system. Even with technical knowledge of the system, instantaneous readings provide little, or no, evidence to determine the health of a battery. An engine driven machine, for example a motorcar, no longer typically includes an instrument for monitoring and indicating battery health, however battery failure remains a common cause of vehicles failing to start.

A service tool is available to check battery performance by applying a high load and monitoring output voltage drop. This instrument is unsuitable for regular use because it uses significant battery charge to carry out the test and the high energy involved requires safe controlled dissipation. This invention avoids these disadvantages.

Objects of the invention include providing an indication of battery health to

- Plan preventative maintenance and battery replacement to avoid failure
- Signal imminent failure to enable operators minimise the effects of failure
- Provide information for optimising a cost effective battery replacement strategy

Accordingly, this invention includes a calibration routine to detect performance of a new battery or system. The battery is monitored throughout service life. By comparison with the information stored at time of calibration, an output is provided to indicate health compared with that when the battery and/or system was new.

The instrument is typically housed for installation into a machine instrument panel or housed for mounting adjacent to or within a battery housing. Electronic circuits provide accurate battery terminal voltage detection, occasional battery loading, and mathematical interpretation of detected voltages and storage of reading in non-volatile memory. The indicated output may be by simple coloured indicator (e.g. green, amber, red), through traditional analogue gauge representation, digitally displayed value(s), or may be communicated electronically via a communication port and suitable protocol (e.g. RS485 Canbus).

Features particularly novel to the invention are

- The instrument remembers original performance characteristics in order to determine deterioration from readings taken later in service.

- Terminal voltage readings are taken and compared to determine reaction to normal in service loads, load pulses controlled by the invention and battery float voltage.
- Multiple readings are taken in order to detect if conditions are present which may introduce interpretation errors (e.g. charge current pulses, load surges). Readings taken while such conditions are present are discarded.
- Readings taken are combined and compared to provide a reading to indicate a serviceability value for the battery.

A Preferred Embodiment

A preferred embodiment of the invention will now be described with reference to the accompanying diagrams.

Figure 1 – a flow chart illustrating the principle of operation
Figure 2 – schematic of an electronic circuit
Figure 3 – example instrument arrangement incorporating the invention.

Principle of Operation

The instrument takes the following measurements in order to indicate battery condition.
Battery Terminal Voltage
Battery Internal Resistance
Volt Drop over fixed period load.
Battery internal resistance is calculated.
Volt drops occurring in service under operational loads.

Calibration

The installer calibrates the instrument by linking an electrical circuit at the connector provided. Calibration must be carried out with battery fully charged, without a battery charger connected. The first phase of calibration stores battery internal resistance IntCal. The second stage of the test measures terminal volt drop during normal machine operation. To complete this the machine should be put through a normal operating sequence, which uses power from the battery. The instrument measures terminal volt drop experienced and stores the value VdropCal. Once the machine has been operated though a normal operational sequence, the calibration link is removed to resume normal operation.

Typical Display Operation

A six-segment indication may be used to display battery health. A typical example of operation is given below.

The health of the battery is displayed according which indicator is lit. Indicator zero signifying poor health, indicator 4 representing health approximately equivalent to that measured at time of calibration, and indicator 5 signalling an improvement in battery health since calibration.

The instrument will carry out the internal resistance check periodically. A typical period may be once per day, however this may vary according to factors including battery size, application duty cycle

The indicator lit firstly depends on float voltage giving a measure of state of charge. This is then modified according to measured internal resistance, and is further modified according to volt drops recorded in recent service.

Float Voltage Indicator level example.

Vfull is the measured battery terminal voltage at time of calibration. Voltage indication span calibrated indicator points, (volts in brackets for 12.7v full charge off charge/load) are: -

Indicator 5 On	Vbat > 107% Vfull	(13.59v)
Indicator 4 On	Vbat > 98% Vfull	(12.44v)
Indicator 3 On	Vbat > 94% Vfull	(11.94v)
Indicator 2 On	Vbat > 90% Vfull	(11.43v)
Indicator 1 On	Vbat > 86% Vfull	(10.92v)
Indicator 0 On	Vbat < 86% Vfull	(10.92v)

Display modification According to Internal Resistance Measurement

IntCal is the internal resistance calculated at time of calibration. IntBat is the internal resistance of the battery most recently calculated during the automatic period load cycle test. Before the display is updated, the on segment is modified as follows

IntBat <= 120% IntCal	No change to health indication.
IntBat >= 120% IntCal and < 150% IntCal	Indicated lower by one segment
IntBat >= 150% IntCal and < 200% IntCal	Indicated lower by two segments
IntBat >= 200% IntCal and < 300% IntCal	Indicated lower by three segments
IntBat >= 300% IntCal	Indicated lower by four segments

Depending on battery type and duty, the above figures may be modified during manufacture to accommodate different health characteristics of the installation.

Display modification According to Measured In Service Volt Drop

VdropCal is the maximum-recorded volt drop in normal operation during calibration. VdropBat is the maximum volt drop recorded in recent service averaged over the last 5 recorded volt drop events.

VdropBat <= 120% VdropCal	No change to health indication.
VdropBat >= 120% VdropCal and < 150% VdropCal	Indicated lower by one segment
VdropBat >= 150% VdropCal and < 200% VdropCal	Indicated lower by two segments
VdropBat >= 200% VdropCal and < 300% VdropCal	Indicated lower by three segments
VdropBat >= 300% VdropCal	Indicated lower by four segments

Depending on battery type and duty, the above figures may be modified during manufacture to accommodate different health characteristics of the installation.

Example Application

An example application for the invention is installation onto a boat. The instrument would be integrated into the driver instrument cluster. When the boat is new, or when a new battery is fitted, the calibration routine is invoked to determine "as new" performance. The instrument would then provide the operator with a battery performance indication. Like other traditional instruments that monitor the engine etc. the indication will assist the operator in recognising that a failure may be imminent, and necessary immediate action can be taken to minimise the effects of a possible failure, and maintenance can be planned.

Claims

1. An instrument for monitoring and indicating electrical battery performance by comparison of in service performance with that when the battery was new.
2. An instrument as claimed in claim 1 where a combination of terminal voltage, terminal voltage change under load in service, terminal voltage under calibrated load are compared with readings taken at time of calibration and a resultant performance.
3. An instrument as claimed in claim 1 and claim 2 whose output is displayed by a series of indicator lights for battery health signalling.
4. An instrument as claimed in claim 1 and claim 2 whose output is displayed by an analogue gauge, either traditional moving pointer device, or graphical representation of same.
5. An instrument as claimed in claim 1 and claim 2 whose output is displayed by a digital numeric value.
6. An instrument as claimed in claim 1 and claim 2 whose output is delivered to a communications network via a data port.
7. A monitoring instrument substantially as herein described and illustrated in the accompanying drawings.

Application No: GB 0109470.5
Claims searched: 1-7

Examiner: David Brunt
Date of search: 14 November 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H2K (KSX)

Int Cl (Ed.7): G01R (31/36)

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2121971 A	(LUCAS) see p.1 ll.54-94	1
X	EP 0447928 A	(MOTO METER) see WPI abstract accession no.1991-282235[41]	1,2
X	EP 0391242 A	(ELEKTRON BREMEN) see WPI abstract accession no.1990-306695[41]	1,2
X	FR 2734061 A1	(THOMSON) see p.1 l.31 - p.2 l.12 and WPI abstract accession no.1997-014258[02]	1
X	US 5454710	(LANDAU) see col.2 ll.21-41	1
X	US 4888716	(UENO) see col.5 ll.17-46	1,2,4
X	US 3808522	(SHARAF) see col.1 ll.23-36	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.